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VISUAL COMMUNICATION IN APHASIA

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Abstract—Aphasic patients who possessed little or no ability to communicate using natural language were taught a visual communication system (VIC). At issue on a theoretical level was whether those cognitive operations entailed in natural language may persist in the face of destruction of natural language capacities. Of practical interest was whether severely aphasic patients could communicate effectively using an alternative symbol system. The program included two levels of communicative functions. At Level 1, patients carried out commands, answered questions, and described actions; at Level 2, patients employed the system spontaneously to express their desires and feelings.

Of 8 patients given sufficient opportunity to master VIC, 5 completed Level 1, and 2 of these also satisfied the criteria for Level 2. Among these 5 patients, performance in VIC far surpassed performance on matching tasks in English; error rates were quite low; the pattern of errors was remarkably similar; an inverse correlation obtained between ability at English and ability at VIC.

The evidence suggests that some severely aphasic patients can master the basics of an alternative symbol system. Moreover several indices suggest that the communicative consequences of the system are appreciated, and that at least some of the cognitive operations entailed in natural language persist despite severe aphasia.

INTRODUCTION

WHETHER patients barred from natural language use by dominant hemisphere damage can effectively communicate via an alternative symbol system is a question of both theoretical and practical importance. This report details a newly devised form of communication for severely aphasic patients. Included is an examination of conceptual issues associated with this undertaking; a report of initial results; an assessment of implications of the findings for both theory and therapy.

It has been reliably established that certain cognitive abilities may remain well-preserved in the presence of a severe aphasia [1, 2]. To this extent natural language abilities, the capacity to produce and comprehend the language system of one's environment, are known to be at least partially dissociated from cognitive operations and underlying various forms of problem solving. Yet, almost nothing is known concerning the central issue to which this research is addressed: the extent to which computational mechanisms involved in language may be preserved in the face of the aphasic's inability to participate in standard oral–aural communication. Indeed, this question proves difficult even to approach in the absence of an agreed list of the capacities entailed in natural language, and the equivalent uncertainty regarding the possible relationships between these capacities and those underlying other rule-governed behaviors [3, 4].

These considerations and goals have dictated a relatively pragmatic attack. Accordingly, the research program has assessed the ability of severely aphasic patients, ones apparently unable to respond or to mediate responses via natural language, to use visual elements to carry out various communicative activities. The particular communicative activities examined, e.g. answering questions, carrying out commands and describing actions, are indisputably important characteristics of natural language communication. Hence, to the extent that aphasic patients master these activities it may be inferred that certain cognitive mechanisms involved in natural language have been preserved.

The communicative activities under consideration presuppose at least the following operations. First, communicators must be able to use the symbols to signal referents, and, more generally, to parse experience in terms of its normal categories: they must distinguish among agents and beneficiaries, events and properties. Second, meaning relations have to be encoded in terms of the configurational properties, or the syntax, of the spatially ordered elements. Finally, the communicators must have the opportunity to use the system in a productive manner. In the present instance, given that some of the visual symbols serve as conjunctions, novel sentences or sentence constituents can be generated.

Despite such similarities between the newly-devised symbol system and natural language, serious problems arise in determining what the successful communicator has mastered. As has been well-documented in studies of child-language [3, 4] and chimpanzee-language learning [5, 6], subjects may appear to have mastered an 'underlying aspect' of a language under one condition, yet fail to evince proper understanding when examined under differing contexts. Establishing that a system designed as a language is in fact being utilized as a vehicle of communication, rather than as a set of carefully programmed language games, is far from a trivial task.

A related problem concerns the manner in which the symbol system is actually acquired by a subject. On the assumption that sequences are not merely memorized, in which case there would be no possibility of language mastery, and that the new system is not being mediated via some other conventional symbol system, acquisition of the visual communication system becomes a totally "bootstrap operation". Almost inevitably, assorted nonsymbolic (or otherwise irrelevant) behaviors will accompany initial stages of learning and may well persist thereafter; these factors compound the difficulty of assessing the subject's proficiency in the symbol system, as a symbol system.

Despite such problems, the possible benefits of providing severely aphasic patients with a new symbol system makes such an effort worthwhile. It has been well documented that many patients with severe expressive impairments and/or comprehension deficits never regain the ability to communicate with those about them [7,8]. Should this failure reflect an underlying inability to utilize any symbolic system, then obviously all efforts at remediation will fail. Aside from the work of VELLETRI-GLASS, GAZZANIGA and PREMACK [9], however, virtually no attempts have been made to train severely aphasic patients to communicate using a symbol system other than natural language. Even their effort was designed primarily to determine whether or not certain basic logical capacities were spared, rather than to establish a framework for functional communication. Therefore, the ultimate communication potential of such aphasic patients remains to be determined.

VISUAL COMMUNICATION

The mediating system designed to explore the communication capacities of severely impaired aphasics has been called VIC, for Visual Communication. VIC messages consist of a series of index cards, on each of which has been drawn a simple, arbitrary (geometric) or representational (ideographic) form denoting a meaningful unit. This symbol system* was chosen over a gestural sign language to circumvent the visual memory deficits and motor-coordination problems common in aphasia. Communicative exchanges occur

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*The term *symbol* is not intended in a technical sense. Other terms which traditionally refer to an information-bearing vehicle, such as *sign* or *token*, can be substituted.

when either the therapist or the patient places a series of cards in front of the other. The addressee responds by choosing from his own set the appropriate cards and placing them on the table, or by carrying out an act responsive to the communication.

Levels of language use

Two levels of this system have been designed for use with aphasic adults. At Level 1, 3 communicative functions are taught in the following order: (1) carrying commands; (2) answering questions; (3) describing events. For those patients who master these tasks, Level 2 training explores their ability to express feelings, immediate needs, and desires via this alternative mode of communication.* A list of all message types appear in Table 1.

Table 1. Message types in VIC

Message Types	Levels Used	Occasion of Use
Commands	1 and 2	Issued by one communicator to another; directs the performance of a physical action (e.g., pick up an object) or a communicative action (e.g., to write a description of an action).
Interrogatives	(2 types)	
A	1 and 2	Used in conjunction with the specific "wh" interrogative particles. Elicits the patient's production of the correct answer regarding a temporally immediate event.
B	2	Used in conjunction with a simple declarative message for truth testing. A "yes" or "no" particle is the desired response.
Simple Declaratives	1 and 2	Used to express wishes such as "I want a cookie" or in response to the description marker.
Phatic or Emotional Utterances	2	Used to comment upon one of the communicator's actions, to express a mood, or to greet another person.

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*The term "Level 2" has been applied for convenience. Unlike Level 1, it is not characterized by the inclusion of specific criteria; rather it refers only to a subjective assessment of communication proficiency clearly extending beyond that charted in Level 1.

Symbol and message types

Symbols are drawn in black ink on blank 3 × 5 index cards, one symbol per card. Selected symbols serving as grammatical morphemes (conjunctions and prepositions) are drawn on smaller, half-sized index cards. Pilot studies demonstrated that symbols which denoted semantic commonality by means of shared visual features proved more difficult for aphasics to learn initially than those which did not. Therefore, VIC symbols within tightly constrained semantic domains (e.g. *give* and *take*) do not possess distinctive features differentiating them from other semantic classes. The only symbols of common design are the interrogative particles requesting specific information, "Who", "What", and "When", which share the unifying symbol design of diagonal stripes but are otherwise visually distinctive. Some typical symbols are illustrated in Fig. 1.

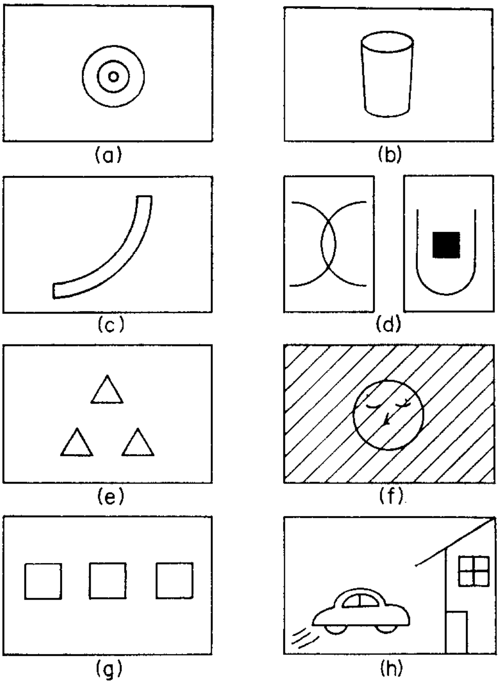

Fig. 1. A selection of symbols used in VIC, with their English translations. (a) Proper Noun, "Lynn" (a therapist's name); (b) Common Noun, "glass"; (c) Verb, "pick up"; (d) Grammatical Morphemes, "and", "in"; (e) Puncuation, "?"; (f) Interrogative Particle, "who"; (g) Metalinguistic Marker, "describe" (or "write it"); (h) Activity Particle, "to go home".

Table 2 outlines the generic classes represented in the VIC symbols utilized in both Level 1 and Level 2 training. Level 1 employs the minimal number of symbols which nonetheless permit adequate evaluation of performance. Even with the set restricted to 5 verbs, 7 nouns, and 3 grammatical morphemes, the total number of transactions between therapist and patient can run into the hundreds.

Syntax

In general, VIC utilizes a linearly ordered (left to right) syntax to signal semantic roles, i.e. to express basic semantic relations between the verb and the various nouns appearing in a VIC sentence. Specifically, the agent of the action appears at the beginning of the sentence, with the objects, locations, and beneficiaries of the action appearing post-verbally in that order. Modality markers appear at the beginning of the utterance for the purpose of emphasis. The following dialogue, translated into English, demonstrates a typical transaction between therapist and patient during Level 1 training. Words implicit in the utterance have been placed in parentheses.

1. Therapist (L): !J pick (up) pencil and comb
   Patient (J): (picks up pencil and comb)
2. Therapist: !Put (pencil and comb) down
   Patient: (puts them down)

Table 2. Symbol types in VIC

Symbol Type	Description	Sample Vocabulary Item Translated into English
Level 1		
Proper Nouns	Arbitrarily designed symbols referring to each VIC communicator; can also function as personal pronouns.	
Common Nouns	Iconic versions of picturable objects.	"glass"
Verbs	Arbitrarily designed symbols.	"shake"
Prepositions	Slightly iconic symbols on half-sized cards.	"in"
Conjunctions	Arbitrarily designed symbols on half-sized cards.	"and"
Request Forms for Specific Information	Corresponding to English "Wh" words.	"who"
Message Category Markers	Arbitrarily designed symbols used to distinguish between interrogative, declarative or emphatic forms.	"?"
Metalinguistic Marker	Single card serving to request a description of an action.	"describe this action"
Level 2		
Interjections	Drawn on half-sized cards.	"true"
Adjectives	Representational drawings of facial expressions, used principally with the verb "feel".	"happy"
Location and Activity Particles	Pictorial scenes. May be used with "when", interrogative, or in simple declarative.	"go home"

3. Therapist: (puts spoon in glass) Describe (the action)
Patient: L put spoon in glass
4. Therapist: !J take pencil (from) L
Patient: (takes pencil from L)
5. Therapist: ?Who take what (from) L
Patient: J take pencil (from) L.

THE STUDY

Subjects

Subjects were selected from the patient population of the Aphasia Research Center of the Boston Veterans Administration Hospital. With one exception (patient W.S.), only patients who were at least 6 months post-ictus and had failed to benefit from standard aphasia therapy were considered. Criterion for selection was a score of 0 or 1 on the Aphasia Severity Rating Scale of the Boston Diagnostic Aphasia Examination [10]; this rating indicates little or no usable speech and comprehension. Twenty-two patients who met this criterion were adminstered VIC pretests of auditory comprehension and oral expression which included items from the Boston Examination as well as English equivalents to Level 1 VIC commands and questions. In addition, candidates for VIC were required to match a series of objects with ideographic drawings of the objects. Seven patients proved unable to match cards to objects. The remaining 15 patients, all of whom had severely impaired natural language skills along with preserved object-drawing matching abilities, were accepted for VIC training. Six patients never completed VIC training due to discharge from the hospital (1 patient), medical complications (2 patients), or inability to master the system despite 3 months' training (3 patients).* Of the remaining 9, 4 are presently in therapy and 5 have completed VIC training, 3 at Level 1, 2 at Level 2. This report focusses on the performance of the 5 patients who successfully mastered the basic properties of VIC. All available information on the neurological status and the intelligence testing of these 5 patients, as well as the 3 patients who failed to master VIC despite 3 months training, is presented in Table 3.

Table 3. Neurological status and intelligence test scores of patients enrolled in VIC for 3 months

Patient	VIC Level Reached	Aphasiological Evaluation by Neurological Staff*	Probable Lesion**	WAIS Performance Score***
S.P.	0	global	large left hemisphere, more anterior than posterior	TOTAL 79; PC-9, BD-4 PA-0, OA-4
S.B.	0	global	large left hemisphere	TOTAL 98; PC-9, BD-8 PA-2, OA-7
M.S.	0	global	distribution of left anterior and middle cerebral arteries--complete left side slowing**	not available
G.M.	1	global	large left hemisphere, more anterior than posterior	TOTAL 109; PC-11, BD-9 PA-8, OA-7
A.P.	1	global	multiple large left hemisphere lesions**	TOTAL 92; PC-8, BD-9 PA-4, OA-7
G.K.	1	impure Broca, mixed aphasia	distribution of left middle cerebral artery-complete left side slowing**	TOTAL 107; PC-8, BD-7 PA-8, OA-9
J.C.****	2	global	large left hemisphere, more anterior than posterior**	TOTAL 78; PC-5, BD-3 PA-5, OA-6
W.S.	2	Wernicke's aphasia/ transcortical sensory	left temporal lobe, possibly extending beyond	TOTAL 106; PC-8, BD-12 PA-12, OA-12

* Consensus reached at aphasia grand rounds where patient was presented to entire staff.

** Asterisks indicate that lesions were verified by brain scan, EEG, or surgery: otherwise lesion localization based on clinical signs (hemiplegia, sensory loss, etc.)

*** WAIS performance score is pro-rated and patient is allowed as much time as he desires. Explanation of sub-tests: PC-Picture Completion; BD-Block Design; PA-Picture Arrangement; OA-Object Assembly.

**** Left-handed

Procedure

Level 1. Patients received approximately 45 min of VIC therapy, 5 days per week, until they had completed Level 1. All VIC training was conducted without spoken English; accordingly, acquisition of the system relied heavily upon the patient's observation of the therapist's actions. The patient's initial encounter with VIC included being assigned an arbitrary symbol representing his VIC "name" as well as parallel exposure to the names of the therapists. To introduce a patient to his "name", the therapist held his name symbol next to the tag he was wearing and showed that they matched. Therapists' and visitors' names were introduced in the same manner. Name cards were worn by all participants throughout training.

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*In 2 of the 3 cases where patients failed to master the system, substantial changes had been made in the therapeutic procedures during the course of training. Failure to master Level 1 may well have been due to inadequacies or inconsistencies in the training procedure.

All new materials in VIC were initially taught using an "observational" or "third party" technique. The patient viewed 2 or more experienced communicators as they modelled the element of construction to be mastered. Eventually, the patient would be drawn into the communicative exchange; for example, a command or question would now be directed at him, rather than at the third person. If he failed to perform the required response, more examples were given until the patient was able to respond correctly to the communication.

For the most part this "naturalistic" means of introduction was employed: the patient was given opportunity to select cards freely and to make errors of various sorts. Social reinforcement by the therapist signalled correct or incorrect performance. But if the patient evinced persistent difficulty with a given construction, a strict drill or operant approach was initiated. At such times the patient's choice of cards or behaviors was severely limited; utterances were varied by only one component at a time; intensive repetitive drill with immediate reinforcement was employed.

The elements and constructions of VIC were introduced in the following prescribed order. In all instances the therapist's assessment of the patient's proficiency determined the schedule for introduction of the next step.

(1) Simple commands using verbs of action which could be readily matched (e.g. "X pick up object"; "X shake object").

(2) Elaborated commands incorporating other parts of speech (e.g. "X pick up A or B", "X pick up A and B", "Place A inside B", "Take object A from person Y"). The difficulty of commands was gradually increased by minimizing cues in the therapeutic environment. For instance, initially the patient would be asked to take candy from a specific person when only that person had candy; in later sessions, other participants would also have pieces of candy.

(3) Questions presented alone (e.g. "? X pick up what"). At first patients had access only to noun symbol cards; they merely had to place the card for the correct object below the "what" particle. Later patients received an entire set of VIC cards and were required to write out a full answer to a question.

(4) Questions and commands presented in random order. The patient was required to switch back and forth between reception and production: in this way his ability to maintain and switch "sets" could be evaluated.

(5) Descriptions presented alone (Communicator carries out an action; using a "write it" card, he or she then directs the patient to describe the recently executed action). This utterance type proved challenging, inasmuch as no cues were available from either therapist or the previous message as to the number of type of cards necessary for a correct description.

(6) Questions, commands, and descriptions intermingled. When the patient could maintain accurate (greater than 80% correct across all utterance types) performance at this sixth stage of proficiency for a two week period, he was considered to have completed Level 1 of VIC training.

Level 2. Level 2 instruction presupposed that the patient had knowledge about the communication system itself, that he understood VIC syntax and the differences in symbol types, and that the new vocabulary items would readily be assimilated into this framework. An enriched and more functional vocabulary included verbs such as "want" and "feel", symbols for common items in a hospital or home environment, "yes" and "no", adjectives and location activity particles. Evidence for a patient's functioning at Level 2 was obtained when he spontaneously wrote out a message in a socially appropriate situation. For example, if a patient wrote out "I want matches" at a time in which environmental cues indicated that he needed or desired matches, but no cue had been given by the therapist, he was assumed to have mastered this aspect of Level 2 training. New vocabulary was added until the patient's discharge from the hospital terminated instruction. At this time, if warranted, the patient's family was taught VIC and asked to continue vocabulary expansion at home.

Measures

Records were kept of each daily therapy session. These included shorthand notation of each transaction including the presence or absence of situational cues, as well as records of the therapist's utterance and the patient's actions for commands, and the patient's response for questions and descriptions. Unless a response was totally correct, it was scored as incorrect and the type of error was noted.

In addition, each patient was given a weekly VIC test as well as naming and auditory comprehension tests in English. The VIC test measured the patient's performance on each of the 3 language components (commands, questions, and descriptions) at his current level of skill; the English counterpart tested the patient's ability to name and to carry out commands in English identical to those given in the VIC test. Scores (percentages correct) on the patient's ability to answer questions and describe events in VIC were also compared to analogous scores on the Boston Examination.

RESULTS

Overall performance

Of the 5 patients who received a full course of VIC instruction, all completed Level 1 and 2 of the 5 completed both levels of VIC training. The mean length of instruction to completion of Level 1 was 5·4 weeks and ranged from 2 to 11 weeks. The various analyses reported in this Results section describe the performance of these 5 patients.

Because of the small number of patients enrolled in the program, it is not possible to determine whether systematic differences in neurological or cognitive status obtained between those patients who failed to learn VIC at all, those who attained Level 1, and those who attained Level 2. The various indices reported in Table 3 do suggest that there were few clear-cut differences among these 3 groups. Nonetheless, it is worth remarking that patients who proved unable to accomplish the Picture Arrangement Sub-test of the WAIS failed at VIC; and that of the 2 patients who attained Level 2, one (J.C.) was left-hand, and the other (W.S.) was the only patient below 50 yr of age as well as the only one whose lesion resulted from trauma, rather than from vascular disease.

Comparison of VIC and English performance

Because a criterion for enrollment in VIC was the inability to describe events in English, any patient who passed through Level 1 necessarily exhibited superior descriptive powers in VIC than in English. More revealing comparisons were possible in the domains of auditory comprehension of commands and the ability to answer questions.

Included in the weekly test session were commands presented in English identical to those given in VIC. Table 4 indicates that 4 of the 5 subjects performed correctly on over 90% of the commands posed in VIC, with the fifth patient handling over 75% of them correctly. In contrast, only 2 of the patients performed at better than a 50% level on comparable commands in English, and in no case did English performance approach proficiency in VIC.

Table 4. Percentage correct responses in comprehension

Patient	Test	
	English Auditory Comprehension	VIC Comprehension of Commands
J. C.	60.0	76.7
G. K.	77.3	100.
G. M.	36.1	98.6
A. P.	43.6	94.5
W. S.	33.3	100.

A further analysis compared patients' ability to provide nominal information in English and in VIC. The patient was required to name objects in English and to answer questions involving names in VIC. Because subjects were exposed to questions at different points and for varying lengths of time, this analysis was based on performance during 3 sessions spaced at equal intervals over the course of training. As can be seen in Table 5, patients uniformly answered such questions better in VIC (range 73–100%) than in English (range 8–20%), even though this measure favors English over VIC. In the former only the name need be provided; in the latter, the total sentence must be provided. Of special interest is the inverse correlation between these measures (Spearman rank order $r = 0{\cdot}82$, $P < 0{\cdot}10$); the better the natural language of the patient, the poorer his use of VIC in answering questions requiring names. These various indices underline the patients' superior communication effectiveness in the new symbol system.

Error analysis

While overall performance in VIC, and its relation to competence in English, were of central interest, supplementary information was also gained through a consideration of the kinds of errors made and the occasions of their occurrence. Of particular interest were the incidence of errors and whether the error pattern proved similar across patients, types of trials, and various stages of the training procedure.

Table 5. Percentage correct responses in production

Patient	Test	
	English Responsive Naming	VIC Questions Requiring Names
J. C.	8.1	92.3
G. K.	17.6	85.6
G. M.	11.7	94.4
A. P.	19.9	72.7
W. S.	11.5	100.

Production vs reception errors. Two main types of errors were isolated. A reception error occurred when a subject failed to execute a command exactly as directed; a production error occurred when manipulation of VIC cards in the course of answering questions or writing descriptions produced an array other than one acceptable in the given context. Subjects were allowed spontaneously to modify their responses in the interval before feedback was given. Within a daily session all transactions except drill trials (i.e. the same transaction deliberately reiterated as part of an operant procedure) were scored.

Overall mastery of VIC during Level 1 was estimated by computing the per cent of each type of error relative to the total number of scorable transactions. As can be seen in Fig. 2, errors were infrequent, but within this context every subject committed more production than reception errors. The mean production error rate was 18% with a range from 11 to 26%; the mean reception error rate was 9% with a range from 2 to 11% (t diff $= 2{\cdot}8$; $P < 0{\cdot}05$). The relatively low error rate indicated the comparative ease with which patients acquired the new symbol system.

Time course of errors. To evaluate change in proficiency during the course of Level 1 training, performance was sampled from a number of points in the four subjects who could

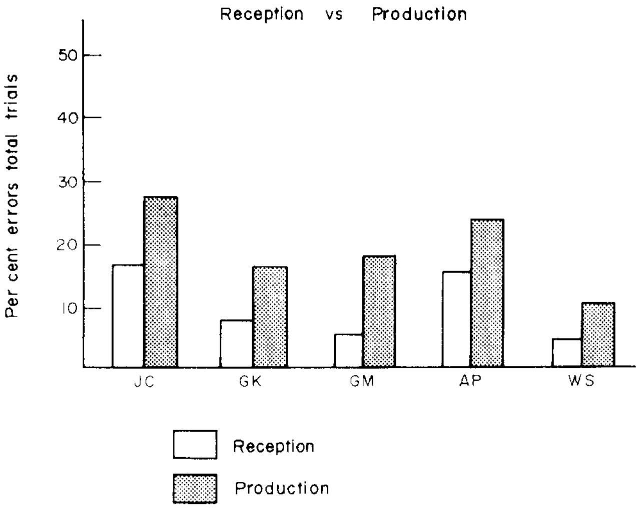

FIG. 2. A comparison of production and reception errors in VIC.

be scored in this way.* Samples of reception performance were taken at 3 separate points: (1) the first 50 command trials, while the subject was exposed only to reception; (2) the first 50 commands after the introduction of production; (3) the last 50 commands before completion of Level 1. Production was sampled from 2 points in time. (1) 50 trials composed of 20 of the first questions plus the first 10 questions and 20 descriptions after the introduction of descriptions; (2) 50 trials from the end of Level 1 training, selected to yield the last 30 questions and 20 descriptions.

Changes in performance can be seen in Table 6. It should be noted that the difference obtained between reception and production occurred in the terminal level, and the rate of reaching it, not in the initial level. Thus trends discerned in the data on reception errors might well have been paralleled in production, had it proved possible to investigate a longer series of trials.

Table 6. Percentage of trials featuring reception and production errors

	Reception Errors			Production Errors	
	Time 1	Time 2	Time 3	Time 2	Time 3
A. P.	26	6	0	26	16
G. M.	18	10	4	20	12
G. K.	22	6	0	20	10
W. S.	4	2	0	10	0

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*Records kept on the fifth subject (J.C.) were made in a slightly different way which precluded a direct comparison.

Types of reception errors. The errors committed on reception trials fell into 4 principal categories: (1) Object Error (O.E.) where the subject executed a command employing the appropriate action but utilizing the wrong object(s); (2) Proper Name Error (N.E.) where the subject involved the wrong person in the interaction (this usually occurred in trials featuring an indirect object); (3) Verb Error (V.E.) where the subject performed the wrong action; (4) Grammatical Morpheme Error (G.M.E.) where the subject confused with one another the preposition and conjunction symbols; both of these were drawn on small cards and shared the property of appearing between the two object–symbol cards.

An analysis taking into account these (and other less common) error types was performed on all Level 1 reception trials which were imperfectly executed. In order to effect comparisons among subjects, in the face of the enormous difference in number of trials, the data were converted into the per cent of total errors represented by each error type. As can be seen in Fig. 3, the pattern of errors proved remarkably similar across subjects.

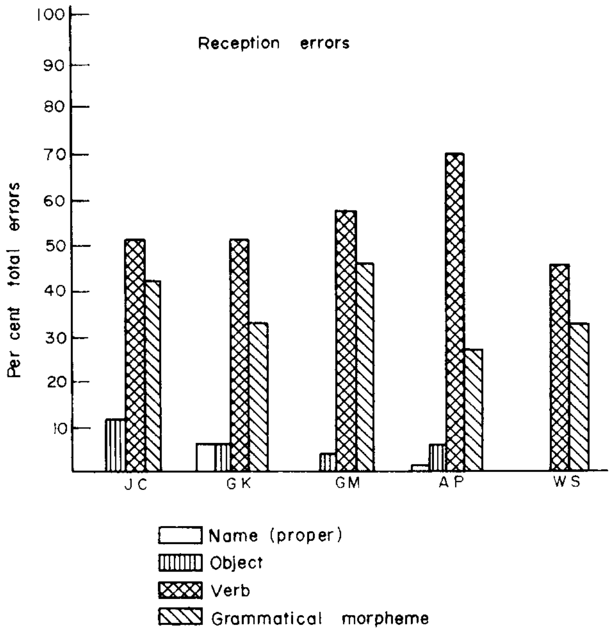

FIG. 3. Pattern of reception errors in VIC. A full description of the error types is offered in the text.

Almost all of the errors fell into two categories (V.E. and G.M.E.) with the verbs consistently posing the greatest problem, either because they were less iconic or because of their more complex (abstract) linguistic function.

Type of production errors. Errors on production trials fell into 4 principal categories: (1) Same Category Error (S.C.E.) where the subject substituted for the correct symbol another symbol from the same form class (e.g. verb A for verb B); (2) Different Category Error (D.C.E.) where the subject placed into an array a symbol that did not perform an appropriate grammatical function (e.g. a verb symbol was placed where a name or object symbol was required); (3) Order Error (O.E.) where the subject placed into the array all symbols required for the utterance but sequenced them inappropriately; (4) Grammatical Morpheme Errors (G.M.E.) where the subject confused with one another the preposition and conjunction symbols.

Results of this analysis can be seen in Fig. 4. Again the high degree of consistency across subjects should be noted. Confusion within a form class (S.C.E.) accounted for the most errors, with 76% of these involving the substitution of one verb for another. The next greatest source of errors were the grammatical morphemes cards (G.M.E.) with the particles "in" and "and" proving most likely to be confused with one another. Proportionately very few errors occurred across form classes (D.C.E.) or in word order (O.E.). The sole exception to this generalization was patient W.S., and his error profile is of limited significance because he made so few errors overall. The general pattern of results—and in particular the small number of O.E. and D.C.E.—suggest that the overall configurational patterns of the system were appreciated by patients; choice of particular verb, and confusion among visually similar particles accounted for the largest percentage of errors. Further evidence for mastery of syntax comes from the ability of certain patients to utilize the appropriate VIC syntax even when the surface form used by the therapist deviated from it in some fashion.

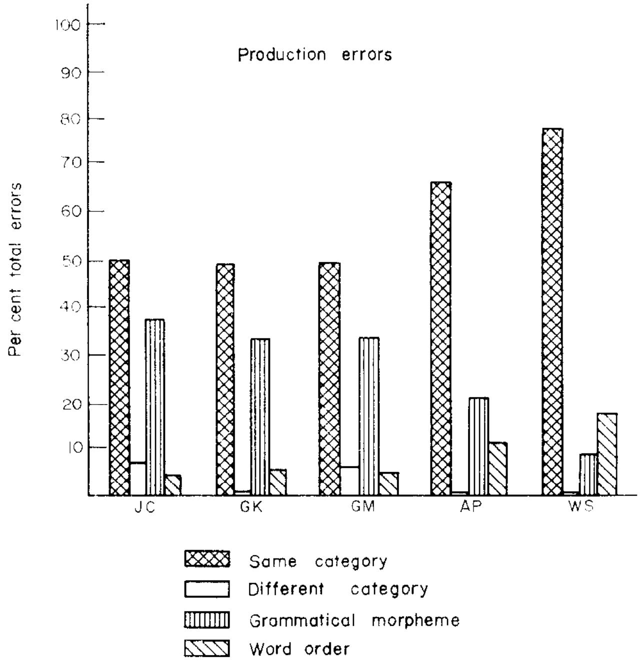

FIG. 4. Pattern of production errors in VIC. A full description of the error types is offered in the text.

Set changes

It is possible that some of the high performance reported above might be artifactual, due to the subjects' acquisition of the appropriate "set". In order to assess the robustness of patients' mastery, their capacity to shift sets (from reception to production or vice versa) or to maintain sets was assessed.

Two types of response set errors were defined: (a) *card use*—when the subject attempted to manipulate his cards (production) when he had been given a command (reception); (b) *object use*—whenever a subject attempted to manipulate an object after being asked to answer a question or describe an event. Both error types were scored for situations where the therapist shifted modes (set change) or where the preceding transaction involved the same mode (set maintenance).

Table 7. Errors in set change and set maintenance

	Reception Trials* (Card Use Error)		Production Trials** (Object Use Error)	
Patient	Following Production	Following Reception	Following Reception	Following Production
W. S.	0	2	0	0
G. M.	16	13	1	0
G. K.	2	9	1	0
A. P.	16	8	0	0
	34	32	2	0

* Errors on reception trials consisted of use of card rather than object.

** Errors on production trials consisted of use of object rather than card.

The principal results of this analysis are presented in Table 7. Findings were contrary to expectations in a number of respects. First of all, the incidence of set change error was quite low; only 2 subjects (G.M. and A.P.) exhibited any difficulty in changing to reception after production. Second, and more surprisingly, patients were as likely to commit a card use error when set was maintained as when set changed: apparently, to the extent that the patients have difficulty, it inheres in maintaining as well as in switching sets. But the effect is not symmetrical in that most errors occur on reception trials. Once the patients have the opportunity to use cards, even though the bulk of their training up to that point has been in the manipulation of objects, they are more likely to err with excessive use of cards. This bias in favor of "symbol" over "object" manipulation is borne out by the low overall number of set errors on production trials.

Other errors

Of particular note was the consistent difficulty displayed by patients in the mastery of antonymic contrasts. Originally, the verb pair of "give" and "take" were introduced contiguously as part of the basic Level 1 vocabulary. Confusion of these two verbs resulted immediately for several patients, at which point "give" was eliminated from VIC vocabulary. Identical results occurred when "left" and "right" were introduced, and that pair was also dropped from the Level 1 vocabulary for this reason. Though antonyms, "pick up" and "put down" were less often confused by patients; this may reflect the compelling necessity for the second verb in situations where it is employed.

A less frequent error involved the substitution of card for object and object for card. Most often this error occurred during early VIC training; overall it accounted for a mean of 2·2% of all patient errors. This form of confusion is reminiscent of the confusion between an object and its name found among young children [11]; it rarely occurred after patients acquired familiarity with the system.

Another error not illustrated in the graphs was the case when the patient failed to respond in any way to the communicative situation, e.g. when the patient failed to answer a question or carry out an act. These "blank outs" accounted for a mean of 3·6% of all errors.

Level 2 performance

Two patients were exposed to the Level 2 vocabulary following completion of Level 1. The performance of one of these patients, who differed in many particulars from the other subjects, has been reported in a separate publication [12]. The following case study outlines the course of the other patient's progress.

J.C., a 52 yr old, left-handed male, suffered a CVA in July, 1973, which resulted in right hemiplegia and aphasia. His language evaluation revealed extremely impaired auditory comprehension and no usable speech. He received a score of "0" on the Aphasia Severity Rating Scale. Seven months post-onset he was dismissed from regular speech therapy after having made "no significant progress" and was subsequently enrolled in VIC therapy. At this time his spontaneous verbal output consisted exclusively of the stereotypes "yes", "wonderful", "Jesus Christ", "hello" and "right".

J.C. was seen in VIC therapy for a total of 10 weeks prior to discharge from the hospital. After 7 weeks he had mastered Level 1 and the 3 remaining weeks were devoted to instruction on such lexical items as "yes", "no", "want", "like", "dislike".

At the end of instruction, J.C. was able to express certain basic needs and desires in VIC. He was able to answer "yes"/"no" questions in VIC with 76% accuracy as compared to his 45% (chance) accuracy in answering English "yes"/"no" questions. Moreover, J.C. spontaneously initiated statements and questions. For instance he regularly asked the therapist in VIC whether she wanted a cigarette and under appropriate circumstances would inquire when he could go home.

J.C.'s discharge from the hospital after 10 weeks of training forced termination of VIC. His wife and children expressed interest in learning VIC themselves and continued the program at home. They were provided with a set of cards and were offered guidelines for the creation of new vocabulary symbols. Their first modification was to change the name cards from arbitrary symbols to small photographs of people mounted on cards. They also added to the VIC lexicon the social amenities of "thank you" and "please".

New medical complications terminated the use of VIC. However, it seemed likely that, without this interruption, VIC would have continued as a supplement to the patient's meager communication skills.

DISCUSSION

Several conclusions emerge from this study: (1) severely aphasic patients can use a system of visual symbols to act upon command, answer questions, and describe actions in their immediate situational environment; (2) certain aphasic patients can go beyond this basic level to express their own wants and feelings in a novel symbol system; (3) the presence of some residual, ineffective natural language may cause more difficulty in the mastery of VIC than a total lack of an ability to map VIC on to natural language; (4) a remarkably similar pattern of errors in reception and production obtains across patients who gain some competence in VIC.

From a practical perspective, therefore, one might claim success for the VIC system. Indeed, given the patients' total inability to communicate via natural language, their capacity to acquire the essentials of VIC is impressive. Yet, before it can be concluded that the mechanisms subserving natural language may remain despite a severe aphasia, two vexed issues must be confronted. While several patients have learned at least certain aspects of VIC, what have they mastered? And what does such mastery suggest about the dissociability of natural language performance from those cognitive operations underlying it?

It seems clear that, if VIC is to serve as an effective vehicle of communication, use of its symbols must satisfy certain rule-bound conditions that determine when the symbols are correctly applied. The use of the "write-it" card, for example, requires that the patient or therapist has performed an act that the other is to describe. Further, it signals that each of the VIC symbols must contribute, and in their entirety, express, a true statement about the activity. But an inference that VIC is being used to communicate such meanings may result from rule-bound behavior that proceeds wholly divorced from a semantic basis.

In this regard an appropriate analogy has been provided by BROWN's [3] analysis of the pigeon-ping-pong problem. Pigeons can be trained to engage in an activity that formally resembles the game of ping-pong. Yet the essence of the game is missing: whatever the activity mastered, the score is not tallied; the pigeons' actions have nothing to do with ping-pong *as a context*. In like fashion, might it not be the case that VIC patients have mastered only a series of "plays" and "sequences"? Might they be responding on the basis of such correlated but communicationally irrelevant conditions as length of utterance, identity of introductory element, or whatever, while ignorant of the communicative impact of the symbols?

Unfortunately, the data do not always permit confident exclusion of this "game-playing" alternative. In a number of instances, and specifically with those patients who failed to attain Level 1, apparent successes in mastering the system have been followed by regressions or even complete losses of the "principles". While some regression and memory loss is to be expected, the completeness of the loss, and the kinds of errors made (such as confusing verbs with nouns), point to an unpalatable conclusion: in certain cases patients no longer have, or indeed may never have had, a fundamental understanding of the operation of the system nor the conditions governing its use. Perhaps, VIC's communicative potential was apparent but the nature of the brain damage precluded any form of symbol retention. Alternatively, the learning may have been simply exclusive of VIC's communicative value. Given the slightest chance to forget the system, or a loss in motivation, the entire learning may collapse of its own weight [13].

Failures of this sort, however, were in the minority. Most patients seemed to display some awareness that VIC was being used to communicate information. This inference is based in part on subjective impressions. But it also finds empirically-demonstrable support in certain patients' tendency to use the system in other than the usual "gaming" situation; in their relatively low error rates; their ability to switch sets; to avoid certain bizarre errors; to correct errors of syntax; to assimilate new items and utterances, and to use these utterances appropriately in different situations. Certainly, the rules governing VIC behavior for the patients who attained Level 2 performance appeared semantic in nature. These patients not only used symbol sequences to codify meaning but also employed the system *spontaneously* to capture their immediate communicative needs.

Even granting that some communication via an alternate symbol system is possible in aphasia, the question remains to what extent such communication embodies the computational mechanisms of natural language. Put differently, can an aphasic with no control of sound-meaning correspondences productively and grammatically use a visually-based symbol system?

Unfortunately, the data do not permit an unequivocal answer to this question. Part of the difficulty in reaching a conclusion stems from the simplicity of the system. VIC's lexicon is sparse and restricted for the most part to familiar and readily available objects and actions; moreover, VIC's syntax consists simply of a left-to-right ordering of elements and its sole source of recursion is conjunction. Nonetheless, it is clear that patients without usable natural language still retain some capacity to communicate as they would in language. They can use symbols to parse experience in terms of its customary categories; they can encode and decode meaning relations in configurational terms—witness the paucity of both symbol-order errors and form-class confusions. Also, to the extent that patients applied the conjunction correctly, when expanding answers to Wh-questions, they seem to show at least some productivity in their use of VIC.

The pattern of successes and failures charted above suggests some immediate questions for future research. For those patients who either seem to approach the enterprise as a series of "informationless" routines or are unable to deal with the complexity of the system, it will be important to determine the critical points of weakness or difficulty, whether these center about reference, the design or configuration of the symbols, or aspects of training. It will also be important to determine what neurological and cognitive features differentiate those who can successfully complete a course in VIC from those who cannot.

As for patients who appear to appreciate VIC as a system of communication, it will be important to determine how much further they can advance. Among avenues currently being explored are the extent to which patients can master concepts of time and causality in VIC; patients' ability to employ "operator cards", which can convert object nouns into agents or locations associated with those objects; the feasibility of capturing the essentials of VIC in a communication medium less cumbersome than the current deck of index cards.

In summary, then, certain severely aphasic patients can learn and utilize an alternative symbol system which bypasses natural language. Still indeterminate is the extent to which such a symbol system can capture the central aspects of natural language, and the degree of success which can be accomplished in the average (and the atypical) aphasic patient. Though mastery of an alternative symbol system is straight-forward when one possesses an already intact natural language, it may well be more advantageous to lack a symbol system than to have a partially impaired system which interferes in the acquisition of an alternative symbol system. Finally, a number of indices suggest that patients utilizing VIC regard the exchange as more than a set of patterns to be memorized or a game to be played at stated times during the day.

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Résumé :

On a appris un système de communication visuelle (CVI) à des malades aphasiques avec peu ou pas de possibilités de communiquer par le langage naturel. Sur le plan théorique, le problème était de savoir si ces opérations cognitives impliquées dans le langage naturel persistent ou non en cas de destruction des capacités du langage naturel. Sur le plan pratique, il était important de savoir si ces sujets profondément aphasiques pouvaient effectivement communiquer en utilisant un autre système symbolique. Le programme comportait 2 niveaux des fonctions de communication. Au niveau I, les malades exécutaient des ordres, répondaient aux questions et décrivaient des actions; au niveau II, les malades utilisaient le système spontanément pour exprimer leurs désirs et sentiments.

Sur les 8 malades auxquels furent données des facilités pour maitriser le CVI, 5 réalisèrent le niveau I et 2 d'entre eux atteignirent également le critère du niveau II. Chez ces 5 malades, les performances au CVI dépassaient de loin les performances sur des épreuves d'appariement en Anglais; les taux d'erreurs étaient très bas; le type des erreurs était remarquablement similaire; une corrélation inverse était obtenue entre les capacités en Anglais et les capacités au CVI.

Ces résultats témoignent que quelques malades gravement aphasiques peuvent maitriser les bases d'un autre système symbolique. En outre, il y a plusieurs indications que les malades réalisent, les conséquences du système du point de vue de la communication et qu'au moins quelques unes des opérations cognitives impliquées dans le langage naturel persistent malgré une aphasie sévère.

Deutschsprachige Zusammenfassung:

Aphasischen Patienten, die wenig oder gar nicht fähig waren, mit Hilfe ihrer natürlichen Sprache zu kommunizieren, wurde ein optisches Kommunikationssystem (VIC) gelehrt.

Zur Entscheidung auf theoretischer Ebene stand, ob diese kognitiven Operationen, die in der natürlichen Sprache angelegt sind, angesichts der Zerstörung des natürlichen Sprachvermögens fortbestehen können. Von praktischem Interesse war, ob schwer aphasische Patienten wirksam genug zu kommunizieren vermochten, indem sie ein Alternativ-Symbol-System verwandten. Das Programm schloß zwei Ebenen kommunikativer Funktionen ein. Auf Ebene I führten die Patienten Befehle aus, beantworteten Fragen und beschrieben Handlungen. Auf Ebene II benützten die Patienten das System spontan, um ihre Wünsche und Gefühle auszudrücken.

Von den acht Patienten, denen ausreichend Gelegenheit gegeben worden war, um das VIC beherrschen zu lernen, brachten fünf Ebene I zustande, und zwei von diesen genügten auch den Kriterien von Ebene II. Bei diesen fünf Patienten übertrafen die Leistungen beim VIC bei weitem ihre Bemühungen, den Aufgaben auf Englisch gerecht zu werden. Die Fehlerquoten waren ziemlich niedrig. Die Fehlermuster waren erstaunlich ähnlich. Eine umgekehrte Korrelation bestand zwischen der in der englischen Sprache gezeigten Fähigkeit und der beim VIC.

Die Anzeichen sprechen dafür, daß einige schwer aphasische Patienten die Grundlagen eines Alternativ-Symbol-Systems bewältigen können. Darüber hinaus legen einige Anzeichen nahe, daß die kommunikativen Konsequenzen des Systems geschätzt werden und daß zumindest einige der kognitiven Operationen, die in der natürlichen Sprache angelegt sind, trotz schwerer Aphasie fortbestehen.